

Syllabus: CHEM 4501

Introduction to Thermodynamics, Kinetics, and Statistical Mechanics

Fall Semester, 2024, MWF 11:15am–12:05pm

Bruininks Hall 220, University of Minnesota, Twin Cities Campus

General Course Information: The main themes of CHEM 4501 include the fundamental underpinnings of molecular thermodynamics and statistical mechanics. In addition to the origins and applications of the fundamentals of thermodynamics (the first, second, and third laws, and free energy at constant volume and constant pressure), this includes an introduction to partition functions and the statistical relationship between molecular and macroscopic observables. Once developed, statistical mechanics and thermodynamics are applied to systems that include ideal gases, more advanced equations of state, phase equilibria, solutions, and chemical equilibria. The course ends with an introduction to chemical kinetics, including differential and integrated rate laws, that extends to reactions beyond first order. This course will help you to understand the chemical world at a deeper level and prepare you to be an informed citizen and life-long learner. This course addresses the University of Minnesota student learning outcomes SLO1, “Can identify, define, and solve problems”, SLO2, “Locate and critically evaluate information” and SLO3, “Master a body of Knowledge and a mode of inquiry.”

Prerequisites: CHEM 1062 or CHEM 1072(H) or CHEM 1082, MATH 2263 or concurrent registration is required (or allowed) in MATH 2263 or MATH 2374 or concurrent registration is required (or allowed) in MATH 2374, PHYS 1302 or PHYS 1402V or PHYS 1502V

Instructor:

Professor Ilja Siepmann

email: siepmann@umn.edu (always use "CHEM 4501" in the subject line)

Office hours: Monday 3:30–4:30pm; Wednesday 12:45–1:45pm; Office: 227 Smith Hall

Teaching Assistants:

Mikayla Fahrenbruch; email: fahre063@umn.edu

Office hours: Tuesday and Thursday 8:30–9:30am; 3rd floor Kolthoff study area (facing the Mall)

Lauren Way; email: way00043@umn.edu

Office hours: Tuesday 11:30am–12:30pm and Thursday 2:30–3:30pm; 3rd floor Kolthoff study area (facing the Mall)

Course Materials:

- **Textbook:** *Physical Chemistry: A Molecular Approach* by Donald A. McQuarrie and John D. Simon. University Science Books, 1997. ISBN:0-935702-99-7.
- **Optional text:** *Problems and Solutions to Accompany Molecular Thermodynamics* by Heather Cox. University Science Books, 1997. ISBN: 0-935702-43-1.
- **iClicker2 Access:** You will need an internet capable device (computer, tablet or phone).
- **Computer:** You will need access to a computer with internet capabilities and working microphone and webcam.
- **For Quizzes and the Final Exam:**
 - Laminated CHEM 4501 equation sheet or a whiteboard along with a dry erase marker
 - A mirror or other highly reflective surface (~6"x6")
 - Non-programmable scientific calculator (see below for specifics)
 - Access to an internet-capable laptop or desktop computer (with webcam and microphone) to access the exam system for quizzes/midterms and the final exam.

Course web site: The course Canvas site can be accessed by going to your myu page at <https://www.myu.umn.edu/>. After you login, click on the MY CLASSES tab and then on the appropriate link for the course Canvas site (CHEM 4501). ***This site will be used for quizzes, exams, and the posting of important announcements, course related materials, and grades.***

How to do well in this course:

- **Be prepared for lecture.** Briefly scan the material that is going to be covered in the lectures before coming to class. It helps to have a basic knowledge of what is being discussed. This can help you tailor questions for material you don't understand.
- **Participate in Class.** Ask questions if there is something that you don't understand.
- **Study the material covered in lecture.** It is helpful to reread your notes while the lecture is still fresh in your mind. If there is something you don't understand, you should ask for help as soon as possible.
- **Work out the assigned problems.** Chemistry can only be mastered by applying concepts learned and the best way to do this is to work problems. Make sure you understand the concepts presented in the chapter and then attempt the problems related to these concepts. The best way to work the problems is without the aid of the solutions manual.
- **Participate in a study group.** Study groups are an effective way of succeeding in this class. Forming a group with 2-3 other students from the class can be a great tool for understanding what you have learned and discover with which concepts you are still struggling, and deepen your knowledge by explaining the material to someone else. Do not go to the study group hoping to learn the material you have not studied, rather complete your studying and take questions to the study group.
- **Get help early.** This class moves very quickly, and we cover a lot of material each week. If you get lost, then don't wait to get help (e.g., discuss with your study group, come to TA or instructor office hours).

Grading: Your final grades will be calculated based on the iClicker problems (maximum of 200 points), 7 quizzes/midterms (6 highest scores, 600 points), and the final exam (200 points).

Grade ranges for this course will be assigned as follows: A: > 900 pts; A-: 850–899 pts; B+: 800–849 pts; B: 750–799 pts; B-: 700–749 pts; C+: 650–699 pts; C: 600–649 pts; C-: 550–599 pts; D+: 500–549 pts; D: 450–499 pts. Using these point ranges, about 60% of the class will receive some type of A or B. These point ranges may be lowered if quiz/exam averages are lower than expected but they will not be raised (go up) if averages are high.

Quizzes/midterms and final exam: Seven quizzes/midterms and one cumulative final exam will be given over the course of the semester. Your lowest score of these quizzes/midterms (#1-7) will be dropped, and only the 6 highest scores will count towards your final grade. The dates and lecture content for each quiz/midterm can be found on the course schedule (see below) and on Canvas/Proctorio. All quizzes/midterms will be open for an 18-hour period from 6:00 am (CDT) to 11:59 pm (CDT) on Thursday. You may log in at any time during this window to complete the quiz/midterm, but you must be finished when the window closes. It is expected that completion of a quiz/midterm will take 60–75 minutes. There is no time limit for the quizzes/midterms imposed by the instructor, but Canvas/Proctorio has an 8-hour time limit and the quiz/midterm must be completed in one sitting, you cannot leave the view of the webcam.

The final exam is scheduled for Thursday, December 19. It will be taken on Canvas/Proctorio and will be open for an 18-hour period from 6:00 am (CDT) to 11:59 pm (CDT). It is expected that completion of the final exam will take two hours.

All quizzes/midterms and the final exam will be completed online using Canvas with Proctorio to monitor exam security. Having online quizzes/exams allows you to take your quiz wherever you can find a quiet spot. **To take your quizzes and final exam this semester you must have an internet connected computer with a working webcam and microphone.**

All quizzes and the final exam will be closed-book and closed-notes and no other study aids are permitted. You must have your student ID (or other form of photo ID) with you to take the exams. The laminated CHEM 4501 equation sheet with blank back page or a blank white board and markers is required to be used for any work (including the long-form question) as no scratch paper will be allowed. A non-programmable calculator can be used (see guideline for specifics below).

Calculators: The presence or use of graphing and/or programmable calculators is not allowed on quizzes/midterms and the final exam; this includes the calculator on your smart phone. Their presence or use during an exam (with the exception of taking a photo of your white board during the final minute of the quiz/exam) will be considered cheating. Only non-programmable calculators with limited memory will be allowed for use during exams. The **TI-30Xa** is the suggested calculator for this and all CHEM 1xxx courses, and for most intro Physics courses. The bookstore stocks this calculator for around \$10. The **TI-30X IIS** is the only acceptable two-line calculator. These are the **ONLY** two calculators that are allowed for exams.

Long-form question(s): The quizzes/midterms and final exams may include one or two long-form questions that require you to show the steps used to solve the problem. Your answer to these questions must fit on the back page of the CHEM 4501 equation sheet or on your white board. At the end of the quiz/exam, you need to hold up the equation sheet/white board to the webcam, then take a photo with your smart phone, then erase the equation/sheet/white board and hold it up to the camera again. The photo of your worked out solution needs to be sent to the teaching assistants within 5 minutes of the end of your Canvas/Proctorio exam session. Sharing the photo with anyone else will be considered a case scholastic dishonesty (see below)

Quiz/Exam Regrade Policy: Regrade requests must be submitted in writing directly to the instructor (via email) within 7 days following the posting of quiz/exam results.

All quizzes/midterms and the final exam must be taken at the times indicated on the Course Schedule. See below on policy for quiz/exam absences. In case of a University-sponsored activity that will prevent the student from access to the Canvas/Proctorio system during the scheduled quiz/exam time, it may be possible to take the exam early.

Policy on Quiz/Exam Absences: The lowest score of the seven quizzes/midterms will not count toward your point total, i.e., you could also be absent from one quiz without excuse. A student can be excused from one additional quiz for a true emergency, serious illness, or University sponsored activity. The student should contact the instructor as soon as circumstances allow and appropriate documentation must be provided (note from physician, coach, etc.). If the circumstances are deemed as appropriate for missing the exam, the unweighted average score of all other quizzes/midterms and of half of the final exam will be used in place of the missed-with-excuse exam. If circumstances lead to a student missing more than one of the six quizzes/midterms counting towards the final grade, then the student should immediately schedule a meeting with the instructor to discuss potential options. **There will be NO late makeup quizzes/midterms given – NO EXCEPTIONS!!**

The final exam can only be missed due to illness or family emergency and documentation must be provided. However, in cases where the final exam is missed an incomplete (“I”) final grade will be assigned according to the policy outlined below.

Policy on an Incomplete (I) Grade: An incomplete grade will be assigned ONLY when the final exam is not taken **AND** the work completed to that date is satisfactory (C- or better). An incomplete grade can only be corrected by taking a regularly scheduled CHEM 4501 final exam in the next available semester. If the final exam is not taken and/or the work completed to that date is not satisfactory, then the point total without the final exam score will be used to determine the grade using the same grade ranges as outlined above. **The “Agreement for Making Up and I Grade” form must be completed and signed by the instructor, student, and a third party within 48 hours of the final exam date.**

iClicker In-class Participation: In-class participation is known to increase student learning! During most lectures, we will work problems. You are allowed and encouraged to work with those sitting near you to discuss solutions. Your responses to some of these problems will be monitored using the iClicker system. These iClicker questions will provide you and the instructor with real-time information on the understanding of concepts covered relatively recently in lecture. You will receive credit for participation (2 points per question) during the iClicker in-class problems, as well as for correct answers (additional 2 points per question). Over the course of the semester, there will be more than 50 questions, but you will only be awarded a maximum of 200 points.

You must correctly register your iClicker device that you will be using to participate in the iClicker questions. You can find information about iClicker registration on the Canvas site. Please see the Canvas site for instructions on setting up polling and comments about wireless network. It is your responsibility to make sure that you bring your device every lecture and that it is connected. If for any reason you miss class, you cannot make up iClicker points. You must be present in the lecture room to earn iClicker points! Having someone else submit iClicker responses for you is an act of scholastic dishonesty; there may be a check for student IDs at the end of one or two randomly selected lectures. Additionally, points will not be awarded for forgetting a device, being absent (excused or unexcused), or being on the wrong wireless network.

Problem Sets (Homework): *Working and understanding the problem sets is very important for doing well in this course.* Problem sets and complete solutions, will be provided and available on the course Canvas site. It is highly recommended that these problem sets are completed in concert with the material coverage schedule provided at the end of this syllabus (about one chapter and associated problem set per week). The problem sets will not be graded. However, the content in the problem sets is fair game for the end of chapter quizzes and exams.

Statement on Extra Credit: There will NOT be any opportunities for extra credit in this course.

Student Conduct Code: As a student at the University, you are expected to adhere to Board of Regents Policy: Student Conduct Code. To review the Student Conduct Code, please see: http://regents.umn.edu/sites/regents.umn.edu/files/policies/Code_of_Conduct.pdf

Scholastic Dishonesty: You are expected to do your own academic work and cite sources as necessary. Failing to do so is scholastic dishonesty. Scholastic dishonesty means plagiarizing; cheating on assignments or examinations; engaging in unauthorized collaboration on academic work; taking, acquiring, or using course materials without faculty permission; submitting false or incomplete records of academic achievement; acting alone or in cooperation with another to falsify records or to obtain dishonestly grades, honors, awards, or professional endorsement; altering, forging, misrepresenting or misusing a University academic record; or depriving another of necessary course materials, and sabotaging another's work. ([Student Conduct Code.](#))

A student guilty of scholastic dishonesty will be awarded a grade of zero (0) for the quiz/midterm (100 points), final exam (200 points), or iClicker problems (200 points) involved. Additionally, the incident will be reported to the Office for Student Academic Integrity and to the college in which the student is enrolled. NO EXCEPTIONS!!

The Office for Community Standards has compiled a useful list of [Frequently Asked Questions](#) pertaining to scholastic dishonesty.

Beware of websites that advertise themselves as being “tutoring websites.” It is not permissible to upload any instructor materials to these sites without their permission or copy material for your own homework assignments from these various sites.

If you have additional questions, please clarify with your instructor for the course. Your instructor can respond to your specific questions regarding what would constitute scholastic dishonesty in the context of a particular class, e.g., whether collaboration on assignments is permitted, requirements and methods for citing sources, if electronic aids are permitted or prohibited during an exam.

For CHEM 4501, collaboration on graded assignments is only acceptable for the iClicker problems. Collaborating with other students in study groups and on the ungraded homework assignments is encouraged, but students need to ensure they can work problems independently in preparation for the exams.

University Policy Statements:

Grade Definitions: <https://policy.umn.edu/education/gradingtranscripts>

Overlapping and Back-to-Back Courses: Enrolling in overlapping or back-to-back courses that do not allow for enough travel time to arrive at our class meetings on time is prohibited. For more information see: <http://policy.umn.edu/Policies/Education/Education/Overlappingclasses.html>

Student Mental Health and Stress Management: As a student you may experience a range of issues that can cause barriers to learning, such as strained relationships, increased anxiety, alcohol/drug problems, feeling down, difficulty concentrating and/or lack of motivation. These mental health concerns or stressful events may lead to diminished academic performance and may reduce your ability to participate in daily activities. University services are available to assist you. You can learn more about the broad range of confidential mental health services available on campus via the [Student Mental Health Website](#). As an instructor/University community member, we care about the wellbeing of students. If health, safety, or mental health concerns are conveyed, we may consult with campus support offices to provide support and resources to a student.

Teaching and Learning: The materials provided in this course are intended only for the students officially enrolled in this section and are to be used to learn and practice the course material. Disseminating class notes, videos, exams, etc.... beyond the classroom community or accepting compensation (in the form of cash or trade, such as access to study website) undermines instructor interests in their intellectual property while not substantially furthering instructor and student interests in effective learning. Such actions violate shared norms and standards of the academic community and are not allowed.

For additional information please see <http://policy.umn.edu/Policies/Education/Education/Studentresp.html>

Equity, Diversity, Equal Opportunity, and Affirmative Action: The University provides equal access to and opportunity in its programs and facilities, without regard to race, color, creed, religion, national origin, gender, age, marital status, familial status, disability, public assistance status, membership or activity in a local commission created for the purpose of dealing with discrimination, veteran status, sexual orientation, gender identity, or gender expression. For more information, please consult Board of Regents Policy: [*Diversity, Equity, Equal Opportunity, and Affirmative Action*](#).

Differently Abled Students: The University of Minnesota is committed to creating learning environments that are inclusive and accessible to all students. If you are experiencing disability-related barriers to learning in your courses, the Disability Resource Center (DRC; <https://disability.umn.edu/>, drc@umn.edu) is the office that collaborates with students to explore reasonable accommodations, tools, and resources.

- If you are registered with the DRC and have a current accommodation letter please share your letter with me as soon as possible so that we can discuss how your accommodations will be implemented in this course. The sooner I know about your disability access-needs, the more equipped I can be to facilitate accommodations. You may reach out to me or your (access consultant/disability specialist) if you have any questions or concerns about your accommodations.

- If you are **not** registered with the DRC and are experiencing or think you may be experiencing disability related to a mental health, attention, learning, chronic health, sensory, or physical condition, and would like to discuss accommodations and/or resources, please contact the DRC on our campus.
- If you have a short-term medical condition, such as a broken arm, I may be able to assist in minimizing classroom barriers. In situations where additional assistance is needed, you should contact the DRC as noted above.

Sexual Harassment, Sexual Assault, Stalking and Relationship Violence: The University prohibits sexual misconduct, and encourages anyone experiencing sexual misconduct to access resources for personal support and reporting. If you want to speak confidentially with someone about an experience of sexual misconduct, please contact a confidential resource on your campus. If you want to report sexual misconduct, or have questions about the University’s policies and procedures related to sexual misconduct, please contact your campus [Title IX office or relevant policy contacts](#).

Instructors are required to share information they learn about possible sexual misconduct with the campus Title IX office that addresses these concerns. This allows a Title IX staff member to reach out to those who have experienced sexual misconduct to provide information about personal support resources and options for investigation. You may talk to instructors about concerns related to sexual misconduct, and they will provide support and keep the information you share private to the extent possible given their University role.

For more information, please see Administrative Policy: [Sexual Harassment, Sexual Assault, Stalking and Relationship Violence](#).

Academic Freedom and Responsibility:

https://regents.umn.edu/sites/regents.umn.edu/files/policies/Academic_Freedom.pdf

Equity, Diversity, Equal Opportunity, and Respect: The University provides equal access to and opportunity in its programs and facilities, without regard to race, color, creed, religion, national origin, gender, age, marital status, familial status, disability, public assistance status, membership or activity in a local commission created for the purpose of dealing with discrimination, veteran status, sexual orientation, gender identity, or gender expression. For more information, please consult Board of Regents Policy: [Diversity, Equity, Equal Opportunity, and Affirmative Action](#). Instructors, teaching assistants, and students are expected to contribute to a respectful, welcoming and inclusive environment for every other member of the class.

For information on the Diversity and Inclusion Committee in the Chemistry Department, see: <https://sites.google.com/umn.edu/chemintranet/diversity-inclusion>

“Collaboration among people of all cultures and backgrounds enhances our experiences and contributes to excellence in teaching, learning, and research. We strive for a climate that celebrates our differences and strengthens our department by embracing and working to increase diversity, equity, and inclusion.”

**This syllabus is available in alternative formats upon request.
Please contact instructor.**

Lecture/Quiz	Date	Topic	Book / Content	Problems
1	W-4-Sep	Introduction	Ch 16, Sec 1	
2	F-6-Sep	Properties of Gases	Ch 16, Sec 2-3	Set 1
3	M-9-Sep	Properties of Gases	Ch 16, Sec 4-5	
4	W-11-Sep	Properties of Gases	Ch 16, Sec 6-7	
5	F-13-Sep	Boltzmann Factor & Partition Functions	Ch 17, Sec 1-2	Set 2
6	M-16-Sep	Boltzmann Factor & Partition Functions	Ch 17, Sec 3-5	
Quiz 1	Tu-17-Sep	Properties of Gases	Ch 16 & Intro Lecture	
7	W-18-Sep	Boltzmann Factor & Partition Functions	Ch 17, Sec 6-8	
8	F-20-Sep	Boltzmann Factor & Partition Functions		Set 3
9	M-23-Sep	Ideal Gas Partition Functions	Ch 18, Sec 1	
10	W-25-Sep	Ideal Gas Partition Functions	Ch 18, Sec 2	
Quiz 2	Th-26-Sep	Boltzmann Factor & IG Partition Functions	Ch 17 & Ch 18, Sec 1-2	
11	F-27-Sep	Ideal Gas Partition Functions	Ch 18, Sec 3-4	Set 4
12	M-30-Sep	Ideal Gas Partition Functions	Ch 18, Sec 5-6	
13	W-2-Oct	Ideal Gas Partition Functions	Ch 18, Sec 7-9	
14	F-4-Oct	First Law	Ch 19, Sec 1-4	Set 5
15	M-7-Oct	First Law	Ch 19, Sec 5-8	
16	W-9-Oct	First Law	Ch 19, Sec 9-12	
Quiz 3	Th-10-Oct	IG Partition Function & First Law	Ch 18 & Ch 19	
17	F-11-Oct	Second Law	Ch 20, Sec 1-3	Set 6
18	M-14-Oct	Second Law	Ch 20, Sec 4-6	
19	W-16-Oct	Second Law	Ch 20, Sec 7-9	
20	F-18-Oct	Third Law	Ch 21, Sec 1-3	Set 7
21	M-21-Oct	Third Law	Ch 21, Sec 4-6	
22	W-23-Oct	Third Law	Ch 21, Sec 7-9	
Quiz 4	Th-24-Oct	Second & Third Laws	Ch 20 & Ch 21	
23	F-25-Oct	Helmholtz & Gibbs Energies	Ch 22, Sec 1-2	Set 8
24	M-28-Oct	Helmholtz & Gibbs Energies	Ch 22, Sec 3-5	
25	W-30-Oct	Review & Work Problems		
26	F-1-Nov	Helmholtz & Gibbs Energies	Ch 22, Sec 6-8	Set 9
27	M-4-Nov	Phase Equilibria	Ch 23, Sec 1-2	
28	W-6-Nov	Phase Equilibria	Ch 23, Sec 3-4	
Quiz 5	Th-7-Nov	Free Energies & Phase Equilibria	Ch 22 & Ch 23, Sec 1-4	
29	F-8-Nov	Phase Equilibria	Ch 23, Sec 5	Set 10
30	M-11-Nov	Liquid-Liquid Solutions	Ch 24, Sec 1-3	
31	W-13-Nov	Liquid-Liquid Solutions	Ch 24, Sec 4-6	
32	F-15-Nov	Liquid-Liquid Solutions	Ch 24, Sec 7-9	Set 11
33	M-18-Nov	Solid-Liquid Solutions	Ch 25, Sec 1-2	
34	W-20-Nov	Solid-Liquid Solutions	Ch 25, Sec 3-4	
Quiz 6	Th-21-Nov	Solutions	Ch 23, Sec 5 & Ch 24 & Ch 25, Sec 3-4	
35	F-22-Nov	Chemical Equilibrium	Ch 26, Sec 1-4	Set 12
36	M-25-Nov	Chemical Equilibrium	Ch 26, Sec 5-7	
	W-27-Nov	No Lecture – Work Problems		
	F-29-Nov	No Lecture – Thanksgiving Break		
37	M-2-Dec	Chemical Equilibrium	Ch 26, Sec 8-11	
38	W-4-Dec	Kinetic Theory of Gases	Ch 27, Sec 1-2 & 6-7	
Quiz 7	Th-5-Dec	Chemical Equilibrium & Kinetic Theory	Ch 26, Sec 1-11 & Ch 27, Sec 1-2 & 6-7	
39	F-6-Dec	Chemical Kinetics	Ch 28, Sec 1-4	Set 13
40	M-9-Dec	Chemical Kinetics	Ch 28, Sec 5 & 7-8	
41	W-11-Dec	Reaction Mechanisms & Dynamics	Ch 29, Sec 1-2 & Ch 30, Sec 1	
Final Exam	Th-19-Dec	All Topics		

